AGE STRUCTURE OF THE NORTHEASTERN SPOTTED DOLPHIN INCIDENTAL KILL BY YEAR FOR 1971 TO 1990 AND 1996 TO 2000

Frederick Archer and Susan J. Chivers

Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
8604 La Jolla Shores Dr.
La Jolla, CA 92037-5018

JUNE 2002

ADMINISTRATIVE REPORT LJ-02-12

ABSTRACT

Using estimates of age made for a sample of 1,106 pantropical spotted dolphins (*Stenella attenuata attenuata*) belonging to the northeastern stock, we generated age frequency distributions for the observed kill of this stock. The aged sample was a subset of the biological samples collected from spotted dolphins incidentally killed in the fishery between 1973 and 1978 and in 1981. Using these data, we estimated the fraction in each age class by color phase and then transformed the color phase tally of spotted dolphins observed incidentally killed into age frequency distributions for each year from 1971 through 1990 and from 1996 through 2000. The age distributions constructed generally resembled that of the age study, although the overall shape of the distribution was somewhat closer to an expected stable age distribution.

INTRODUCTION

Age is traditionally the parameter used to quantify rates of birth and survival for modeling population dynamics. The underlying age structure of a population is rarely known for wild animals, particularly cetaceans, and a stable age distribution is generally assumed. However, data on the age structure of animals taken in a harvest or incidentally killed in a fishery facilitates the assessment of potential effects of takes on the population's dynamics. And the assessment of the impact of the yellowfin tuna purse-seine fishery on dolphin stocks is no exception.

The northeastern stock of pantropical spotted dolphin (*Stenella attenuata attenuata*) is the most frequently set-on dolphin species in the eastern tropical Pacific tuna purse-seine fishery (Smith *et al*. 1983; Wade 1995). High mortality levels prior to the early 1970s (Wade 1995) led to its designation as depleted under the U.S. Marine Mammal Protection Act. The stock has been the focus of an extensive series of life history studies designed to better understand the biology of this species and the effect of the fishery (see Perrin and Hohn 1994 for review).

One life history study conducted in the early 1980s estimated age for spotted dolphin specimens collected during fishery operations between 1973 and 1978 and in 1981. The age data was used to examine the age structure of the kill (Barlow and Hohn 1984) and to estimate age-specific rates of growth and reproduction (Myrick *et al*. 1986). Barlow and Hohn (1984) present the age distribution that resulted from that study and note that 0 to 2 year-old and 5 to 15 year-old age classes were under represented relative to a stable age distribution. The under representation of 0 to 2 year-olds was expected, because teeth were not routinely collected from small animals sampled from the tuna fishery, but the under representation of 5 to 15 year-olds was unexpected and difficult to explain. By comparing the annual age frequency distributions for the years represented in the study, they ruled out the hypothesis that the observed distribution reflected the true age structure of the population. That is, there was no evidence of an under represented cohort moving through the population. However, alternate hypotheses of sampling bias, perhaps resulting from the fishery not setting on dolphin herds with those age classes, and of aging errors could not be ruled out as explanations for the shape of the age distribution.

The goal of our analyses was to re-construct the age structure of the incidental kill for the northeastern stock of spotted dolphin to aid in the current assessment of the stock (see Wade 2002). We used the age distribution by color phase data available from the spotted dolphin age study to construct these distributions for as many years as possible from 1971 to the present.

METHODS

Incidental kill by color phase data

For every spotted dolphin killed during tuna purse-seine operations, observers record the sex and number in each color phase (Neonate, Two-Tone, Speckled, Mottled, and Fused – Perrin 1969). From the National Marine Fishery Service (NMFS) set-log and tally databases, we obtained the number of northeastern spotted dolphins in each color phase observed killed annually for 1971 to 1990. The Inter-American Tropical Tuna Commission (IATTC) provided the same data for 1996 to 2000. Because some dolphins did not have a color phase recorded, the total number of dolphins in a given color phase for each year (N_{cy}) was estimated as,

$$N_{cy} = n_{cy} + \left(nu_y \times \frac{n_{cy}}{\sum_c n_{cy}} \right),$$

where c is one of the five color phases (Neonate to Fused), y is the year, n_{cy} is the number of dolphins observed in that color phase, and nu_y is the number of dolphins without a recorded color phase.

Age data

As time permitted, NMFS observers also collected biological data and tissue samples from a subset of the incidental kill. A random sample of all available specimens with total body length recorded and teeth collected between 1973 and 1978 was selected for age determination. Male and female spotted dolphins were aged in the study. Later, ages for all female spotted dolphin with total body length recorded and teeth collected in 1981 were estimated and added to the data set.

Age was estimated by counting growth layer groups (GLGs) in the dentine and cementum of the prepared tooth sections (Myrick *et al*. 1983). Identified GLGs in the spotted dolphin teeth were interpreted as annual events, because calibration experiments conducted with Hawaiian spinner dolphins (Myrick *et al*. 1984) and bottlenose dolphins (Hohn *et al*. 1989; Myrick and Cornell 1990) found that GLGs were deposited annually. Two readers independently read each specimen. The 1973-78 specimens were read at least three times by each reader, while each of the 1981 specimens were aged only once by each reader. Because age estimates were significantly different between readers for the 1973-78 specimens (Reilly *et al*. 1983), a pooled mean estimate of age for each specimen was calculated as the average of the two readers estimates. We used the pooled mean age estimates in our analyses.

Age structure of the observed incidental kill

The spotted dolphin age study included age estimates for 1,094 female spotted dolphin specimens and 798 male specimens. Of these, 649 females and 457 males belonged to the northeastern stock and had color phase recorded. These 1,106 specimens were used to generate the age frequency distribution for each age class and color phase (F_{ac}),

$$F_{ac} = \frac{S_{ac}}{\sum_{a} S_{ac}},$$

where S_{ac} is the number of samples of age a in color phase c.

To construct annual age distributions from the set-log and tally data, we first calculated the number of dolphins in each age class a, color phase c and year y (N_{acy}),

$$N_{acy} = F_{ac} \times N_{cy}.$$

The total number of dolphins in each age class and year (N_{ay}) is then the sum of N_{acy} across color phases,

$$N_{ay} = \sum_{c} N_{acy}.$$

This value is expressed as a fraction by dividing it by the total number of dolphins in all age classes in a given year,

$$F_{ay} = \frac{N_{ay}}{\sum_{a} N_{ay}}.$$

By using a color-age frequency distribution (F_{ac}) generated from samples collected primarily during the 1970s, we have made the assumption that the relationship between color phase and age does not vary appreciably over time. Perrin (1969) suggested that the change from mottled to fused color patterns coincided with the attainment of sexual maturity, which can occur between the ages of 10 and 17 (Myrick *et al*. 1986). If the change from mottled to fused color phases is more related to attainment of sexual maturity than it is to age, a change in the age at attainment of sexual maturity could introduce a bias in our age distributions constructed for later years.

To examine this effect, we used a subset of the mottled and fused specimens sampled from the incidental kill that had an estimate of age available and state of sexual maturity determined. Males were judged sexually mature if all products of spermatogenesis were observed during histological examination of the testes tissue (Hohn *et al*. 1985), and females were considered sexually mature if one or more corpora albicantia or a corpus luteum was observed during examination of the ovaries (Perrin *et al*. 1976). We fit a logistic regression,

$$\Pr(\mathit{fused}) = \frac{1}{1+e^{-\alpha-\beta_1 Age-\beta_2 Maturity}},$$

to the data, where α, β_1, and β_2 are the estimated coefficients, and *Maturity* was scored as 0 for immature and 1 for mature. Models were fit to male and female data separately.

RESULTS AND DISCUSSION

The frequency of age class by color phase for the sample of 1,106 aged dolphins is presented in Table 1 and Figure 1. The number of spotted dolphins in each color phase that were observed incidentally killed from 1971 to 1990 and 1996 to 2000 is given in Table 2. For each of these years, the age structure of the observed incidental kill that we obtained is presented in Table 3 and Figure 2.

Our frequency-based method of re-constructing the age structure of the kill resulted in age distributions that resembled that of the age study sample. That is, the 5 to 15 year-old age classes were generally under represented, as they were in the age study sample (Barlow and Hohn 1984; Fig. 3). Even so, overall, the age structure of the kill that we constructed appears more like an expected stable age distribution. In particular, there are more young animals (age classes 0 – 3) in our re-constructed age distributions than in the aged sample (Fig. 3). These similarities and differences further emphasizes the fact that 0 to 3 year olds are under represented in the subset of animals sampled from the kill and lends support to the hypothesis that juvenile spotted dolphins (*i.e*., 5 to 15 year-olds) are not in the herds set on by the purse-seine fleet.

In Figure 2, it is apparent that the estimated age distributions are fairly consistent across years. This is a direct reflection of the relatively stable distribution of color phases in the observed incidental kill across years (Fig. 4). 1983 is an anomalous year as the kill of northeastern spotted dolphins dropped to 173 from 1,696 in 1982. This is most likely the result of a shift in the area of operations by the tuna fleet to the west in response to El Niño conditions (IATTC 1984).

Although the color phases (Neonate, Two-Tone, Speckled, Mottled, and Fused) are roughly correlated with age, there is overlap (Fig. 1) and determinations can be subjective, particularly when dolphins are transitioning to the next color phase (Perrin 1969; Perrin *et al*. 1976). As both NMFS and IATTC observers use the same color phase definitions, random subjectivity is not expected to affect our estimates. Support for this assertion is provided by the relatively stable color phase distributions observed from year to year.

Table 4 gives the regression coefficients for the logistic relationship of color phase to age and sexual maturity. For both the male and female samples, the range of the upper and lower 95% confidence limits of the odds ratio is larger for maturity than for age. This implies that, with our data, age is a better predictor than state of sexual maturity of color phase. Thus, our age-color frequency distribution should not be appreciably affected if age at attainment of sexual maturity changes over time.

This analysis could be further refined by including bootstrap estimates of variance for each year via random re-sampling of the aged sample as well as the observed sets within each year.

ACKNOWLEDGEMENTS

The authors wish to thank Dr. Robin Allen, Dr. Michael Scott, and Nick Vogel of the IATTC and Al Jackson of NMFS for providing data for the analysis. We greatly appreciate the assistance of Bill Perrin, Tim Gerrodette, Jay Barlow, Wayne Perryman, and Dave Bratten for many helpful discussions.

LITERATURE CITED

Barlow, J. and P. L. Boveng. 1991. Modeling mortality for marine mammal populations. Marine Mammal Science 7:50-65.

Barlow, J., and A. A. Hohn. 1984. Interpreting spotted dolphin age distributions. NOAA-Technical Memorandum. –NMFS-SWFC-48. 22pp.

Hohn, A. A., S. J. Chivers, and J. Barlow. 1985. Reproductive maturity and seasonality of male spotted dolphins, *Stenella attenuata*, in the eastern tropical Pacific. Marine Mammal Science 1:273-293.

Hohn, A. A., M. D. Scott, R. S. Wells, J. C. Sweeney, and A. B. Irvine. 1989. Growth layers in teeth from known-age, free-ranging bottlenose dolphins. Marine Mammal Science 5:315-342.

Inter-American Tropical Tuna Commission. 1985. Annual Report of the Inter-American Tropical Tuna Commission: 1984. La Jolla, California. 270 pp.

Myrick, A. C., Jr., and L. H. Cornell. 1990. Calibrating dental layers in captive bottlenose dolphins from serial tetracycline labels and tooth extractions. Pages 587-608 *in* S. Leatherwood and R. R. Reeves, eds. *The Bottlenose Dolphin*. Academic Press, New York.

Myrick, A.C., A. A. Hohn, J. Barlow, and P. A. Sloan. 1986. Reproductive biology of female spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific. Fishery Bulletin 84: 247-259.

Myrick, A. C., Jr., A. A. Hohn, P. A. Sloan, M. Kimura, and D. D. Stanley. 1983. Estimating age of spotted and spinner dolphins (*Stenella attenuata* and *Stenella longirostris*) from teeth. NOAA-Technical Memorandum –NMFS-SWFC-30. 17pp.

Myrick, A. C., Jr., E. W. Shallenberger, I. Kang, and D. B. MacKay. 1984. Calibration of dental layers in seven captive Hawaiian spinner dolphins, Stenella longirostris, based on tetracycline labeling. Fishery Bulletin 82:207-225.

Perrin, W. F., 1969. Color pattern of the eastern Pacific spotted porpoise *Stenella graffmani Lonnberg* (Cetacea, Delphinidae). Zoological Journal, New York Zoological Society 54: 135-149.

Perrin, W. F., and A. A. Hohn. 1995. Pantropical spotted dolphin *stenella attenuata*. Handbook of Marine Mammals 5: 71-98.

Perrin, W. F., J. M. Coe, and J. R. Zweifel. 1976. Growth and reproduction of the spotted porpoise, *Stenella attenuata*, in the offshore eastern tropical Pacific. Fishery Bulletin 74:229-269.

Reilly, S. B., A. A. Hohn, and A. C. Myrick Jr. 1983. Precision of age determination of northern offshore spotted dolphins. NOAA- Technical Memorandum –NMFS-SWFC-35. 27pp.

Smith, T.D. 1983. Changes in size of three dolphin (Stenella spp.) populations in the eastern tropical Pacific. Fish. Bull. 81:1-13.

Wade, P. R. 1995. Revised estimates of dolphin kill in the eastern tropical Pacific, 1959-1972. Fishery Bulletin 93:345-354.

Wade, P. 2002. Assessment of the population dynamics of the northeastern offshore spotted and the eastern spinner dolphin populations through 2002. Administrative Report No. LJ-02-13, NMFS, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

Table 1. Proportion of each age class in each color phase (F_{acy} – see text for description) in the sample of 1,106 aged specimens of the northeastern stock of pantropical spotted dolphin (*Stenella attenuata attenuata*).

Age	Neonate	Two-Tone	Speckled	Mottled	Fused
0	0.864	0.141	0.000	0.000	0.000
1	0.136	0.329	0.000	0.000	0.000
2	0.000	0.241	0.017	0.005	0.000
3	0.000	0.188	0.157	0.016	0.002
4	0.000	0.059	0.163	0.016	0.000
5	0.000	0.029	0.134	0.022	0.002
6	0.000	0.000	0.116	0.038	0.005
7	0.000	0.006	0.099	0.048	0.004
8	0.000	0.006	0.070	0.086	0.002
9	0.000	0.000	0.076	0.086	0.009
10	0.000	0.000	0.029	0.118	0.013
11	0.000	0.000	0.029	0.134	0.031
12	0.000	0.000	0.017	0.081	0.023
13	0.000	0.000	0.017	0.054	0.027
14	0.000	0.000	0.023	0.059	0.032
15	0.000	0.000	0.012	0.070	0.063
16	0.000	0.000	0.012	0.048	0.074
17	0.000	0.000	0.006	0.016	0.074
18	0.000	0.000	0.012	0.011	0.067
19	0.000	0.000	0.000	0.022	0.081
20	0.000	0.000	0.000	0.016	0.063
21	0.000	0.000	0.000	0.005	0.063
22	0.000	0.000	0.000	0.000	0.058
23	0.000	0.000	0.006	0.000	0.072
24	0.000	0.000	0.000	0.016	0.036
25	0.000	0.000	0.000	0.005	0.052
26	0.000	0.000	0.000	0.000	0.043
27	0.000	0.000	0.000	0.005	0.023
28	0.000	0.000	0.000	0.005	0.018
29	0.000	0.000	0.006	0.000	0.011
30	0.000	0.000	0.000	0.011	0.018
31	0.000	0.000	0.000	0.000	0.009
32	0.000	0.000	0.000	0.000	0.007
33	0.000	0.000	0.000	0.000	0.011
34	0.000	0.000	0.000	0.005	0.002
35	0.000	0.000	0.000	0.000	0.002
36	0.000	0.000	0.000	0.000	0.005

Table 2. The observed incidental kill (or tally) of the northeastern stock of pantropical spotted dolphin (*Stenella attenuata attenuata*) by color phase for years: 1971 to 1990 (National Marine Fisheries Service data) and 1996 to 2000 (Inter-American Tropical Tuna Commission data).

Year	Neonate	Two-Tone	Speckled	Mottled	Fused	Total
1971	86	147	108	151	269	761
1972	252	718	532	497	2,461	4,460
1973	271	536	573	603	1,699	3,682
1974	281	1,156	807	763	2,568	5,574
1975	751	1,240	933	1,054	2,888	6,866
1976	145	492	366	388	953	2,344
1977	91	371	272	314	1,081	2,129
1978	45	198	148	147	466	1,005
1979	44	166	169	158	464	1,001
1980	39	169	179	149	543	1,079
1981	30	127	131	149	373	810
1982	57	257	285	318	779	1,696
1983	6	17	11	33	106	173
1984	19	46	54	55	120	294
1985	121	370	381	525	1,229	2,625
1986	103	264	306	338	801	1,812
1987	116	479	469	525	1,730	3,319
1988	45	171	186	225	509	1,136
1989	65	178	157	164	534	1,099
1990	43	82	53	58	257	493
1996	43	100	71	76	322	612
1997	31	71	40	49	200	391
1998	19	31	29	34	87	200
1999	19	39	29	30	117	235
2000	15	33	16	20	114	198

Table 3. Re-constructed annual age frequency distributions for the northeastern stock of pantropical spotted dolphin (*Stenella attenuata attenuata*) incidentally killed: 1971 to 1980.

Age	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**
0	0.1248	0.0715	0.0841	0.0728	0.1199	0.0831	0.0617	0.0665	0.0610	0.0534
1	0.0789	0.0607	0.0580	0.0752	0.0744	0.0776	0.0633	0.0711	0.0606	0.0566
2	0.0500	0.0415	0.0387	0.0533	0.0468	0.0543	0.0451	0.0510	0.0438	0.0415
3	0.0624	0.0518	0.0553	0.0648	0.0586	0.0674	0.0562	0.0635	0.0611	0.0586
4	0.0376	0.0307	0.0365	0.0380	0.0352	0.0404	0.0334	0.0380	0.0398	0.0384
5	0.0295	0.0241	0.0294	0.0292	0.0275	0.0313	0.0263	0.0295	0.0317	0.0306
6	0.0259	0.0210	0.0268	0.0245	0.0238	0.0266	0.0231	0.0252	0.0281	0.0272
7	0.0260	0.0201	0.0258	0.0238	0.0234	0.0261	0.0226	0.0245	0.0270	0.0258
8	0.0287	0.0198	0.0266	0.0239	0.0245	0.0271	0.0235	0.0249	0.0272	0.0252
9	0.0310	0.0236	0.0300	0.0269	0.0273	0.0297	0.0269	0.0279	0.0305	0.0289
10	0.0321	0.0236	0.0297	0.0262	0.0274	0.0292	0.0275	0.0275	0.0294	0.0275
11	0.0417	0.0353	0.0406	0.0367	0.0374	0.0392	0.0390	0.0382	0.0403	0.0387
12	0.0268	0.0240	0.0267	0.0243	0.0246	0.0256	0.0260	0.0252	0.0265	0.0258
13	0.0227	0.0230	0.0240	0.0223	0.0220	0.0226	0.0238	0.0230	0.0239	0.0239
14	0.0265	0.0272	0.0282	0.0264	0.0259	0.0266	0.0281	0.0271	0.0283	0.0283
15	0.0378	0.0439	0.0423	0.0402	0.0388	0.0390	0.0437	0.0411	0.0422	0.0433
16	0.0374	0.0475	0.0438	0.0423	0.0400	0.0398	0.0460	0.0430	0.0438	0.0457
17	0.0301	0.0432	0.0376	0.0370	0.0343	0.0336	0.0406	0.0374	0.0377	0.0403
18	0.0273	0.0393	0.0343	0.0338	0.0312	0.0306	0.0369	0.0341	0.0345	0.0369
19	0.0329	0.0471	0.0409	0.0402	0.0373	0.0365	0.0443	0.0407	0.0409	0.0437
20	0.0255	0.0365	0.0317	0.0312	0.0290	0.0283	0.0343	0.0316	0.0317	0.0339
21	0.0233	0.0353	0.0299	0.0297	0.0273	0.0265	0.0327	0.0300	0.0300	0.0324
22	0.0204	0.0318	0.0266	0.0265	0.0242	0.0234	0.0292	0.0267	0.0267	0.0290
23	0.0263	0.0404	0.0341	0.0340	0.0311	0.0302	0.0373	0.0342	0.0343	0.0372
24	0.0159	0.0216	0.0192	0.0188	0.0176	0.0173	0.0206	0.0190	0.0192	0.0203
25	0.0195	0.0294	0.0249	0.0248	0.0228	0.0221	0.0273	0.0250	0.0250	0.0270
26	0.0153	0.0238	0.0199	0.0199	0.0182	0.0175	0.0219	0.0200	0.0200	0.0217
27	0.0093	0.0135	0.0117	0.0115	0.0107	0.0104	0.0127	0.0116	0.0117	0.0125
28	0.0074	0.0105	0.0092	0.0090	0.0084	0.0082	0.0099	0.0091	0.0092	0.0098
29	0.0046	0.0066	0.0059	0.0058	0.0053	0.0053	0.0062	0.0059	0.0060	0.0064
30	0.0085	0.0111	0.0101	0.0098	0.0092	0.0091	0.0107	0.0099	0.0100	0.0105
31	0.0032	0.0050	0.0041	0.0041	0.0038	0.0037	0.0046	0.0042	0.0042	0.0045
32	0.0025	0.0040	0.0033	0.0033	0.0030	0.0029	0.0037	0.0033	0.0033	0.0036
33	0.0038	0.0060	0.0050	0.0050	0.0045	0.0044	0.0055	0.0050	0.0050	0.0054
34	0.0017	0.0016	0.0017	0.0016	0.0016	0.0016	0.0017	0.0016	0.0017	0.0016
35	0.0006	0.0010	0.0008	0.0008	0.0008	0.0007	0.0009	0.0008	0.0008	0.0009
36	0.0019	0.0030	0.0025	0.0025	0.0023	0.0022	0.0027	0.0025	0.0025	0.0027

Table 3 (cont.). Re-constructed annual age frequency distributions for the northeastern stock of pantropical spotted dolphin (*Stenella attenuata attenuata*) incidentally killed: 1981 to 1990.

Age	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
0	0.0537	0.0504	0.0415	0.0777	0.0596	0.0697	0.0505	0.0555	0.0737	0.0989
1	0.0567	0.0545	0.0363	0.0602	0.0527	0.0557	0.0523	0.0551	0.0615	0.0669
2	0.0417	0.0405	0.0255	0.0418	0.0376	0.0391	0.0381	0.0403	0.0425	0.0428
3	0.0588	0.0588	0.0326	0.0618	0.0534	0.0577	0.0528	0.0581	0.0563	0.0510
4	0.0385	0.0393	0.0193	0.0420	0.0352	0.0390	0.0340	0.0387	0.0353	0.0291
5	0.0310	0.0318	0.0167	0.0338	0.0287	0.0317	0.0275	0.0314	0.0280	0.0226
6	0.0282	0.0291	0.0181	0.0305	0.0269	0.0290	0.0252	0.0289	0.0249	0.0197
7	0.0275	0.0282	0.0185	0.0296	0.0265	0.0282	0.0244	0.0282	0.0241	0.0191
8	0.0289	0.0296	0.0228	0.0306	0.0290	0.0295	0.0253	0.0301	0.0247	0.0196
9	0.0322	0.0330	0.0270	0.0337	0.0324	0.0328	0.0290	0.0334	0.0281	0.0229
10	0.0323	0.0328	0.0325	0.0327	0.0338	0.0326	0.0294	0.0338	0.0280	0.0237
11	0.0436	0.0441	0.0466	0.0431	0.0454	0.0435	0.0413	0.0451	0.0391	0.0350
12	0.0285	0.0288	0.0311	0.0279	0.0296	0.0283	0.0274	0.0293	0.0259	0.0236
13	0.0252	0.0254	0.0281	0.0243	0.0259	0.0249	0.0250	0.0256	0.0237	0.0223
14	0.0296	0.0299	0.0328	0.0286	0.0304	0.0293	0.0295	0.0300	0.0279	0.0263
15	0.0437	0.0440	0.0529	0.0410	0.0451	0.0428	0.0455	0.0439	0.0427	0.0423
16	0.0447	0.0449	0.0553	0.0414	0.0459	0.0436	0.0477	0.0445	0.0447	0.0454
17	0.0378	0.0379	0.0487	0.0342	0.0386	0.0366	0.0418	0.0372	0.0391	0.0409
18	0.0345	0.0345	0.0436	0.0313	0.0350	0.0334	0.0380	0.0339	0.0356	0.0372
19	0.0412	0.0412	0.0538	0.0371	0.0422	0.0398	0.0456	0.0405	0.0425	0.0447
20	0.0319	0.0319	0.0417	0.0288	0.0327	0.0308	0.0354	0.0314	0.0330	0.0347
21	0.0300	0.0299	0.0396	0.0267	0.0305	0.0288	0.0337	0.0293	0.0314	0.0334
22	0.0265	0.0264	0.0353	0.0235	0.0269	0.0254	0.0300	0.0258	0.0280	0.0300
23	0.0340	0.0340	0.0445	0.0305	0.0345	0.0328	0.0383	0.0332	0.0358	0.0381
24	0.0195	0.0195	0.0252	0.0177	0.0201	0.0189	0.0213	0.0193	0.0199	0.0206
25	0.0250	0.0250	0.0330	0.0223	0.0255	0.0241	0.0280	0.0244	0.0261	0.0278
26	0.0199	0.0198	0.0265	0.0176	0.0202	0.0191	0.0225	0.0193	0.0210	0.0225
27	0.0118	0.0117	0.0154	0.0106	0.0120	0.0113	0.0130	0.0115	0.0122	0.0128
28	0.0093	0.0093	0.0121	0.0084	0.0095	0.0090	0.0102	0.0091	0.0095	0.0100
29	0.0059	0.0059	0.0070	0.0055	0.0059	0.0058	0.0064	0.0058	0.0061	0.0062
30	0.0103	0.0103	0.0131	0.0094	0.0106	0.0100	0.0111	0.0102	0.0103	0.0106
31	0.0041	0.0041	0.0055	0.0037	0.0042	0.0040	0.0047	0.0040	0.0044	0.0047
32	0.0033	0.0033	0.0044	0.0029	0.0034	0.0032	0.0038	0.0032	0.0035	0.0037
33	0.0050	0.0050	0.0066	0.0044	0.0051	0.0048	0.0056	0.0048	0.0052	0.0056
34	0.0018	0.0018	0.0021	0.0017	0.0019	0.0018	0.0018	0.0019	0.0017	0.0016
35	0.0008	0.0008	0.0011	0.0007	0.0008	0.0008	0.0009	0.0008	0.0009	0.0009
36	0.0025	0.0025	0.0033	0.0022	0.0025	0.0024	0.0028	0.0024	0.0026	0.0028

Table 3 (cont.). Re-constructed annual age frequency distributions for the northeastern stock of pantropical spotted dolphins (*Stenella attenuata attenuata*) incidentally killed: 1996 to 2000.

Age	**1996**	**1997**	**1998**	**1999**	**2000**
0	0.0838	0.0945	0.1037	0.0950	0.0881
1	0.0634	0.0703	0.0647	0.0659	0.0651
2	0.0421	0.0460	0.0414	0.0429	0.0422
3	0.0518	0.0532	0.0558	0.0537	0.0467
4	0.0304	0.0295	0.0355	0.0321	0.0246
5	0.0239	0.0227	0.0284	0.0252	0.0189
6	0.0210	0.0195	0.0256	0.0220	0.0163
7	0.0203	0.0191	0.0250	0.0213	0.0160
8	0.0207	0.0199	0.0264	0.0217	0.0165
9	0.0242	0.0231	0.0294	0.0250	0.0201
10	0.0247	0.0242	0.0298	0.0252	0.0218
11	0.0362	0.0354	0.0403	0.0362	0.0338
12	0.0244	0.0238	0.0264	0.0242	0.0232
13	0.0229	0.0223	0.0234	0.0226	0.0225
14	0.0271	0.0263	0.0275	0.0267	0.0266
15	0.0432	0.0421	0.0409	0.0418	0.0443
16	0.0462	0.0450	0.0419	0.0444	0.0483
17	0.0415	0.0403	0.0356	0.0395	0.0445
18	0.0377	0.0366	0.0324	0.0359	0.0403
19	0.0453	0.0441	0.0388	0.0430	0.0487
20	0.0351	0.0342	0.0301	0.0334	0.0378
21	0.0338	0.0329	0.0282	0.0320	0.0367
22	0.0303	0.0295	0.0250	0.0286	0.0331
23	0.0385	0.0374	0.0321	0.0365	0.0418
24	0.0209	0.0204	0.0183	0.0200	0.0223
25	0.0281	0.0274	0.0235	0.0266	0.0305
26	0.0227	0.0221	0.0187	0.0215	0.0248
27	0.0130	0.0126	0.0111	0.0123	0.0140
28	0.0101	0.0099	0.0087	0.0096	0.0109
29	0.0063	0.0061	0.0055	0.0061	0.0067
30	0.0108	0.0105	0.0096	0.0103	0.0114
31	0.0047	0.0046	0.0039	0.0045	0.0052
32	0.0038	0.0037	0.0031	0.0036	0.0041
33	0.0057	0.0055	0.0047	0.0054	0.0062
34	0.0016	0.0016	0.0017	0.0016	0.0016
35	0.0009	0.0009	0.0008	0.0009	0.0010
36	0.0028	0.0028	0.0023	0.0027	0.0031

Table 4. Results of logistic regression of the mottled to fused color phase transition by state of sexual maturity and age.

Males (n = 269)

Parameter	Estimate	S.E.	p	Odds ratio	Lower 95%	Upper 95%
α (constant)	-4.887	1.021	> 0.0005			
β_1 (Age)	0.327	0.077	> 0.0005	1.386	1.192	1.612
β_2 (Maturity)	2.145	0.586	> 0.0005	8.540	2.708	26.930

Females (n = 415)

Parameter	Estimate	S.E.	p	Odds ratio	Lower 95%	Upper 95%
α (constant)	-2.652	0.507	> 0.0005			
β_1 (Age)	0.151	0.038	> 0.0005	1.163	1.080	1.252
β_2 (Maturity)	1.861	0.407	> 0.0005	6.430	2.894	14.289

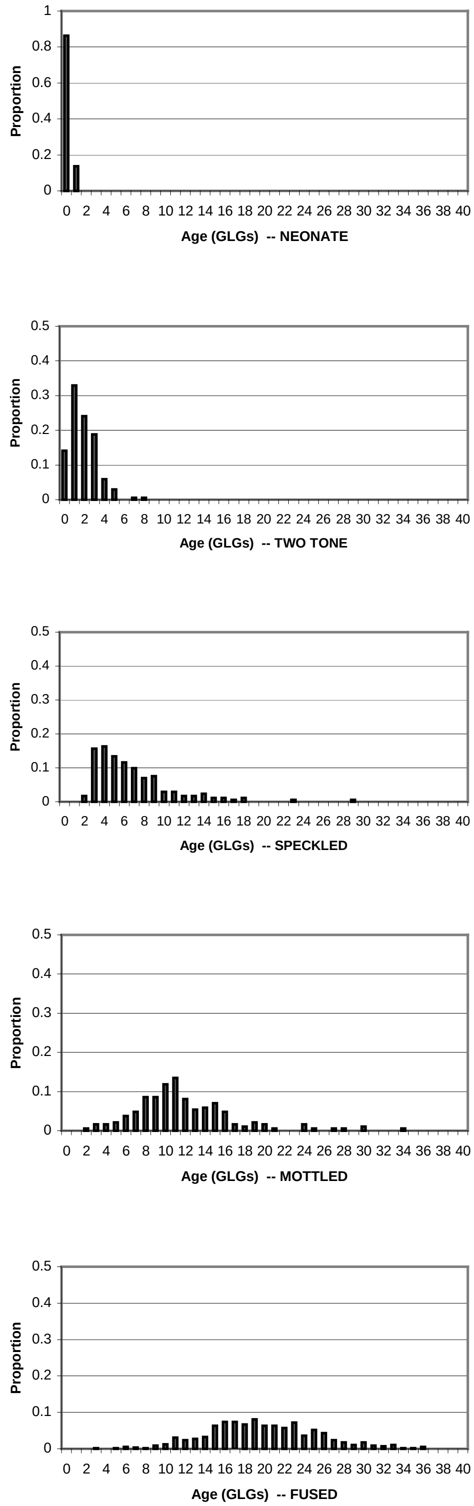


Figure 1. Proportion of the 1,106 northeastern stock of pantropical spotted dolphin (*Stenella attenuata attenuata*) specimens aged by color phase. Note: The scale for the plot of the neonate color phase is different from all others.

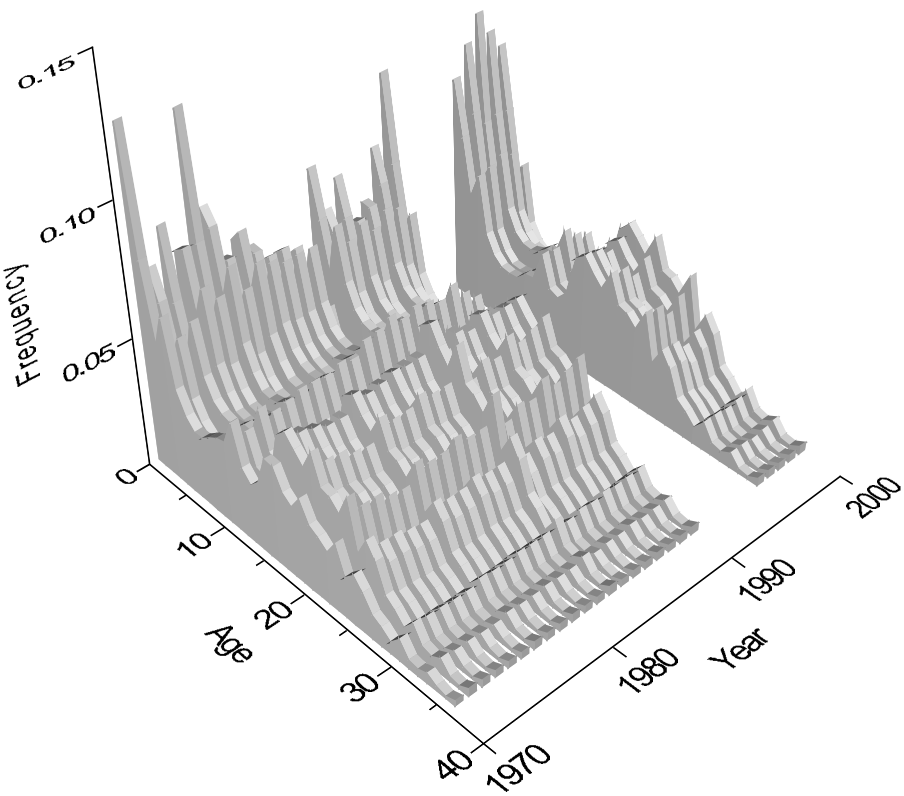
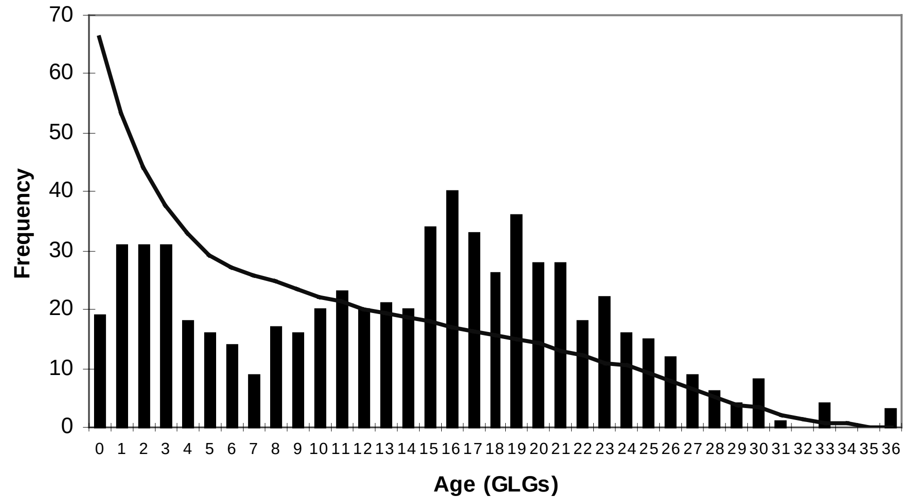


Figure 2. Age frequency distributions constructed for the observed incidental kill of the northeastern stock of pantropical spotted dolphin (*Stenella attenuata attenuata*) for each year: 1971-1990 and 1996-2000.

(a)



(b)

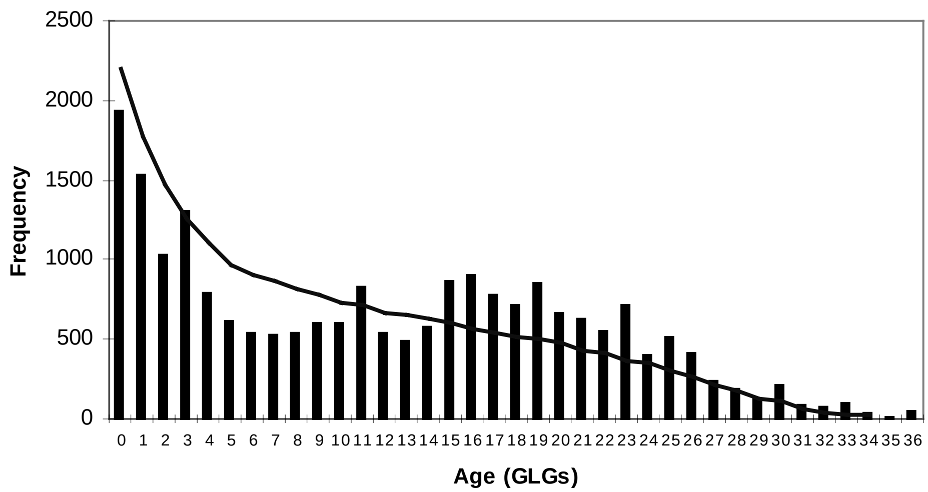


Figure 3. (a) The age frequency distribution of the northeastern stock of pantropical spotted dolphin (*Stenella attenuata attenuata*) specimens aged in the aging study (Barlow and Hohn, 1984; Myrick et al., 1986). (b) The re-constructed age frequency distribution for years 1973-1978 combined. The solid line in both panels represents a typical stable age distribution for a sample of the same size. The estimation of age-specific survival rates used to generate the stable age distribution was based on the parameters in Barlow and Boveng (1991).

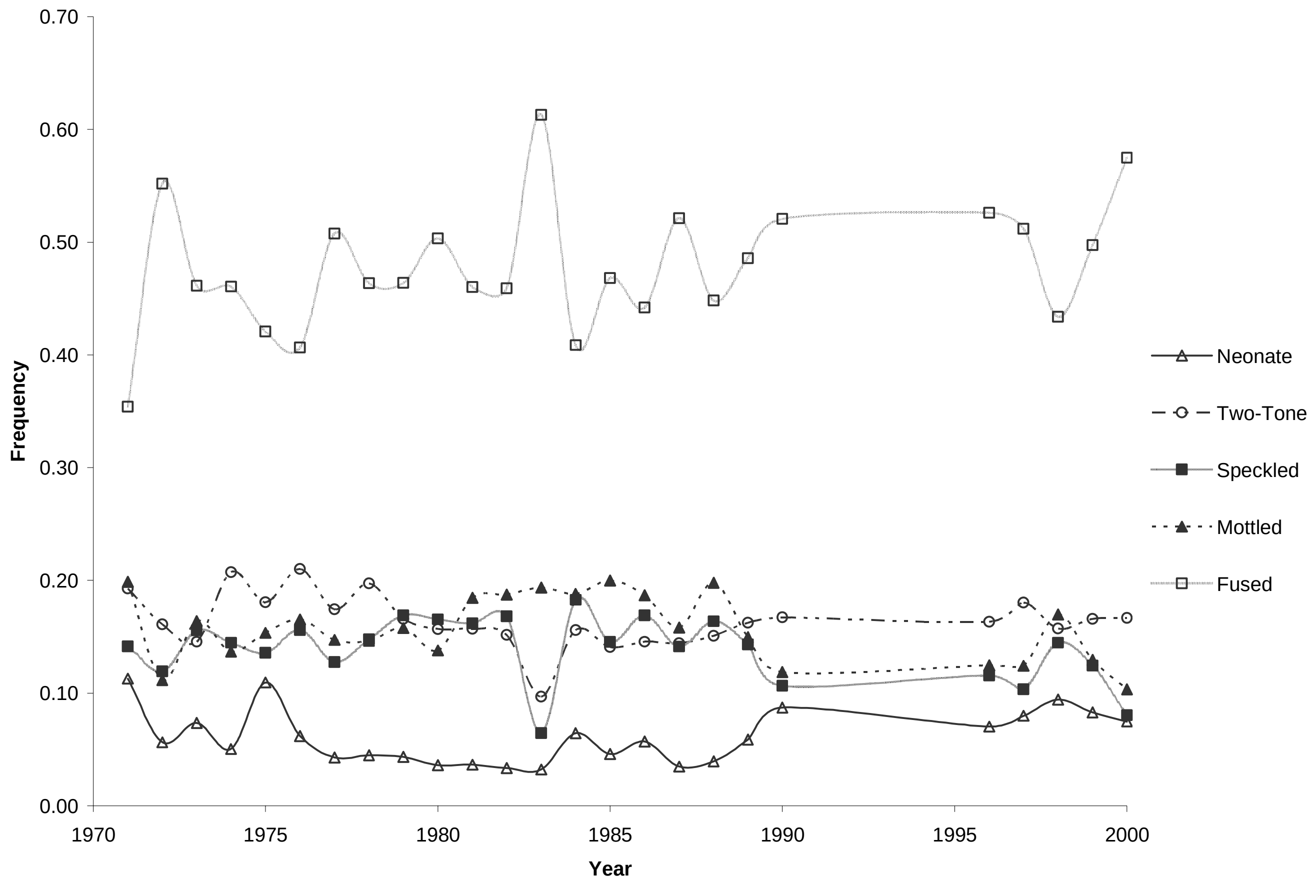


Figure 4. Mean annual frequency of color phase recorded for the observed incidental kill of the northeastern stock of pantropical spotted dolphins (*Stenella attenuata attenuata*) for years: 1971 – 1990 and 1996-2000.